Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: December 1, 1971

to: Distribution

from: K. P. Klaasen

subject: Utilization of LRV Power for the LCRU -- Case 310

B71 12004

ABSTRACT

An analysis has been made of a proposal to use LRV power for the LCRU and to reduce the number of LCRU batteries carried from three to two. The following conclusions are drawn:

1) Two LRV batteries provide ample energy for LRV, LCRU, and post-EVA TV requirements. Hence, LCRU batteries should be used only in contingencies. Using LRV power for the LCRU eliminates the time required to switch from LCRU to LRV power or to change LCRU batteries during an EVA.

2) The nominal traverse plan cannot be performed on only one LRV battery, so LCRU batteries would have to be used if an LRV battery fails. Two LCRU batteries provide a reserve of about 35% above nominal LRV energy requirements. Three LCRU batteries provide a 55% reserve.

3) If the LRV is not available, three LCRU batteries will provide voice communication through the LCRU on three walking traverses. Two LCRU batteries should also be able to provide voice communication on three walking traverses provided the LCRU is used only when communications through the LM are unsatisfactory.

4) If the D/C to D/C converter (which allows use of LRV batteries to power the LCRU) fails, LCRU batteries must be used. Three LCRU batteries provide about 10.3 hr of TV (out of 15 hr nominal) if the LM is used for voice communication when possible. Two LCRU batteries provide 6.6 hr of TV.

5) Deleting one LCRU battery saves about 9 lb of LM descent stage weight (equivalent to 1/2 sec of descent hover time).

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MEMORANDUM FOR FILE

On Apollo 15, three batteries were carried to provide power for the LCRU, one for each lunar surface EVA. The LRV was powered by two of its own batteries used simultaneously. Preliminary analyses of the LCRU energy requirements for Apollo 16 show that the energy required on each of the three EVA's will exceed the capability of a single LCRU battery. Therefore, time will be required to switch the LCRU from internal to LRV power during each EVA and to change LCRU batteries on EVA's 2 and 3. The time required for the switch over to LRV power is insignificant if it is performed at a planned station stop. About 3 or 4 minutes are required to change LCRU batteries. In order to eliminate this overhead time, MSC has proposed that all power required for LCRU operation be supplied by the LRV batteries. Apollo 15 experience has shown that the LRV batteries have sufficient capacity to power both systems. If LRV power is used for the LCRU, the LCRU batteries become a contingency source of power. MSC maintains that only two LCRU batteries provide sufficient energy for any reasonable contingency. Therefore, they also propose deletion of one LCRU battery with a resulting LM descent stage weight savings of 9 lb (equivalent to 1/2 sec of descent hover time). An analysis of these proposals follows.

Battery Capacities and Energy Requirements

The LRV batteries contain a specification minimum of 121 amp-hr of charge; however, the last 6 amp-hr of each battery are considered unusable. Therefore, the LRV batteries are assumed to provide 115 amp-hr, or 4140 watt-hr, of usable energy. The LCRU batteries are expected to provide 400 watt-hr of usable energy.

On Apollo 15, the LRV required an average of 67.3 watt-hr/km. LRV Operations Handbook data indicate that a 10% increase in power consumption due to the rougher terrain at Descartes is a reasonable estimate. Thus, 72 watt-hr/km is assumed to be the Apollo 16 LRV requirement.

The LCRU is assumed to require 124 watts with the TV on and 74 watts with the TV off when powered from the LRV. These requirements are reduced about 15 watts each when LCRU internal power is used because the D/C to D/C converter between the LRV batteries and the LCRU is no longer in the circuit.

The Apollo 16 traverses will involve a total of about 30 km of actual lunar distance. The LCRU will be powered up for about 18.5 hr, 15 hr with the TV on and 3.5 hr with the TV off.

The total energy requirements for all three EVA's on Apollo 16 when both the LRV and LCRU use LRV power are:

2120	watt-hr for the LCRU
2160	watt-hr for the LRV
4280	watt-hr total.

Any post-EVA TV will require further energy. If LCRU batteries are used to power the LCRU, the total energy requirement is reduced by about 60 watt-hr per LCRU battery used to depletion.

Conclusions

The following conclusions are drawn:

1. Two LRV batteries provide ample energy for LRV, LCRU, and post-EVA TV requirements. Hence, LCRU batteries should be used only in case of contingencies. Using LRV power for the LCRU eliminates the time required to switch from LCRU to LRV power or to change LCRU batteries during an EVA.

2. The nominal traverse plan cannot be performed on only one LRV battery, so LCRU batteries would have to be used if an LRV battery fails. Using two LCRU batteries to depletion will leave an LRV battery reserve of about 35% beyond the nominal 2160-watt-hr LRV energy requirement. Three LCRU batteries provide a 55% reserve. The LRV power consumption rate could go almost as high as 100 watt-hr/km without exceeding the capability of one LRV battery plus two LCRU batteries.

3. If the LRV is not available, three LCRU batteries will provide voice communication through the LCRU on three walking traverses. Two LCRU batteries should also be able to provide voice communication on three walking traverses provided the LCRU is used only when communications through the LM are unsatisfactory.

4. If the D/C to D/C converter fails, LCRU batteries must be used to power the LCRU. Three LCRU batteries provide about

10.3 hr of TV if the LM is used for voice communication relay when possible (assumes the LCRU is required for voice-only communications only when traveling in the area of North Ray Crater and Smoky Mountain on EVA 3). Two LCRU batteries provide 6.6 hr of TV.

5. Deleting one LCRU battery saves about 9 lb of descent stage weight.

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